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DECLARATION

I,Noboru YOSHIDA, of SHIGA INTERNATIONAL PATENT OFFICE, 2-3-1, Yaesu, Chuo-ku, Tokyo, Japan, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. 2000-163612 and that all statements made herein are true to the best of my knowledge.

Declared in Tokyo, Japan

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(Item)	Specification	1
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[Document Type] SPECIFICATION

[Title of the Invention] FRICTION REDUCING SHIP

[Claims]

[Claim 1] A friction reducing ship that reduces frictional resistance of a ship body by ejecting gas bubbles on a submerged surface of the ship body, comprising:

a negative pressure forming section protruding from the submerged surface of the ship body for creating a negative pressure region in the water having a lower pressure relative to a gaseous space;

a discharge opening for ejecting the gas bubbles towards the negative pressure region in the water; and

a fluid passage having one end open to the gaseous space and having the other end open in the water by way of the discharge opening so as to direct a gas from the gaseous space into the water; wherein

the discharge opening is disposed on an inclined surface inclined at an angle to the submerged surface of the ship body.

[Claim 2] A friction reducing ship according to claim 1, wherein the inclined surface is disposed to extend from an inner portion to an outer portion of a depression provided on the submerged surface of the ship body.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to a friction reducing ship in which frictional resistance of a ship body is reduced, and in particular, to improving the total energy efficiency by efficiently ejecting bubbles into the water.

[0002]

[Prior Art]

Conventionally, methods have been proposed for the purpose of reducing energy consumption when a vessel or the like is cruising, in which bubbles are ejected into the water and frictional resistance between a ship body and the water is reduced by interposing a multitude of bubbles in the vicinity of the surface (submerged surface) of the outer hull of the ship body.

[0003]

Techniques of generating bubbles in the water are proposed in Japanese Unexamined Patent Applications, First Publication Nos. Sho 50-83992, Sho 53-136289, Sho 60-139586, Sho 61-71290, and in Japanese Unexamined Utility Model Applications, First Publication Nos. Sho 61-39691 and Sho 61-128185.

[0004]

In these techniques, methods for generating bubbles in the water rely on equipment such as pumps and blowers to eject pressurized gas into the water through a plurality of holes or porous plates provided on the ship body.

[0005]

[Problems to be Solved by the Invention]

However, the method of ejecting pressurized gas into the water presents a problem in that energy is needed in operating the pressurizing equipment so that it results in a loss of part of the energy savings achieved by reducing the frictional resistance. Especially, if the gas is ejected into the water from relatively deep locations below the surface such as at the bottom surface of large capacity vessels, it is necessary to pressurize the gas to a higher pressure relative to the water pressure (static pressure), thus resulting in expending

a large amount of energy. Also, when providing pressurizing equipment in the ship body, high costs such as installation and operating costs are generated.

[0006]

This invention is provided in view of the above circumstances, and the objectives of the invention are as follows.

(1) To effectively reduce the energy consumption during cruising by lowering the frictional resistance at a lower energy consumption.

(2) To mix bubbles into the water efficiently to achieve effective reduction in frictional resistance.

(3) To reduce the cost of constructing the ship body.

[0007]

[Means for Solving the Problems]

In order to solve the above-mentioned problems, the invention according to claim 1 adopts, in a friction reducing ship for reducing the frictional resistance of a ship body by ejecting bubbles on the submerged surface of the ship body, a technique of providing a negative pressure forming section protruding from the submerged surface of the ship body for creating a negative pressure region in the water having a lower pressure relative to a gaseous space; a discharge opening for ejecting the gas bubbles towards the negative pressure region in the water; and a fluid passage having one end open to the gaseous space and having the other end open in the water by way of the discharge opening so as to direct a gas from the gaseous space into the water; wherein the discharge opening is disposed on an inclined surface inclined at an angle to the submerged surface of the ship body.

Furthermore, the invention according to claim 2 adopts a technique wherein the inclined surface is disposed to extend from an inner portion to an outer portion of a

depression provided on the submerged surface of the ship body.

[0008]

According to this invention, since a negative pressure region is formed in the water having a pressure lower than a pressure in a gaseous space due to a negative pressure forming section, a gas is directed from the gaseous space into the water via a fluid passage by means of a pressure gradient force, and bubbles are ejected into the water via a discharge opening. Because the discharge opening is disposed on an inclined surface inclined at an angle to the submerged surface of the ship body, the surface area of the opening of the discharge opening can be enlarged readily within a given region of the submerged surface. Further, because the inclined surface, on which this discharge opening is disposed, extends from an inner portion to an outer portion of a depression provided on the submerged surface of the ship body, by having at least a portion of the discharge opening within the depression, the height of protrusion of the inclined surface from the submerged surface of the ship body can be controlled even when a discharge opening having a large opening area is provided. Therefore, a large amount of bubbles can be ejected from the discharge opening having a large opening area while suppressing any increase in the resistance force against the flow of water.

[0009]

[Embodiments of the Invention]

Below, an embodiment will be described with reference to the figures, wherein the friction reducing ship according to this invention is applied to a bulk ship such as a tanker or freighter.

In Fig. 2, reference symbol M is a friction reducing ship, 10 is a ship body, 11 is a bubble generation apparatus, 12 is a ship body outer hull (submerged surface), 13 is a

screw, 14 is a rudder, and 15 is the water surface (waterline).

[0010]

A VLCC (Very Large Crude Oil Carrier), for example, corresponds to the bulk ship as the friction reducing ship M. In comparison with other types of vessels, the surface area on the bottom of the ship is formed to be relatively large in comparison with the side of the ship in the ship body outer hull 12 (submerged surface) which is beneath the waterline 15. Moreover, the bubble generation apparatus 11 is disposed at the front of the ship body 10 (bow side).

[0011]

As shown in Fig. 2(b), the bubble generation apparatus 11 is constituted by a fluid guiding body 20 disposed at an opening 12a provided on the bottom of the ship, and an air induction pipe (AIP) 21 connected to this fluid guiding body 20.

[0012]

The fluid guiding body 20 is constructed overall as a component member of a pipe-shape having a hollow internal section, and flanges 22, 23 for connecting to the air induction pipe 21 or to the ship body outer hull 12 are provided at both ends in the axial direction. Also, as shown in Fig. 3, at the end of the side connected to the ship body outer hull 12 (lower end) is provided a fore-inclined surface 24 serving as the negative pressure forming section that extends at an angle to the axial direction and faces the forward direction (bow side), and an aft-inclined surface 25 disposed at the rear surface side and facing the rear of the forward direction (stern side), and a portion of the edges of these inclined surfaces 24, 25 are coupled together so as to form a protrusion having a spear shape. Here, the aft-inclined surface 25 is provided with a discharge opening 26 comprising a through-hole and acting as a hollow opening for the fluid guiding body 20.

[0013]

Returning to Fig. 2, the air induction pipe 21 is constituted primarily of pipe shaped members, and is installed roughly through the ship body and is connected to the fluid guiding body 20 via a flange 27. By connecting the air induction pipe 21 and the fluid guiding body 20, a fluid passage 30, serving as the internal space thereof, is formed. The fluid passage 30 is open at one end to a gaseous space (atmosphere) by way of an air intake opening 21a of the air induction pipe 21, while the other end opens into the water by way of the discharge opening 26. Here, the cross sectional area and shape of the fluid passage 30 (internal space of the fluid guiding body 20 and the air induction pipe 21) are set so that a desired amount of the fluid flows at a low pressure loss.

[0014]

Here, the shape and positioning of each component of the bubble generation apparatus 11 are designed by flow field analysis of CFD (Computational Fluid Dynamics) or the results of cruising experiments so as to obtain the desired shape of the flow of water at the rear of the fluid guiding body 20 during cruising.

In this case, the fore-inclined surface 24 of the fluid guiding body 20 is disposed so as to protrude at a certain height H from the submerged surface 12 of the ship body during cruising at a given speed Vs so that a negative pressure region having a pressure lower than the gaseous space (atmosphere) is formed in the water at the rear of the fluid guiding body 20 by the flow of water relative to the ship body.

[0015]

Also, by connecting the fluid guiding body 20 to the ship body outer hull 12, a depression 31 is formed on the submerged surface 12 of the ship body, and the aft-inclined surface 25 of the fluid guiding body 20 is disposed at an angle to the

submerged surface 12 of the ship body from the inside portion to the outside portion of the depression 31 so that the discharge opening 26 provided in the aft-inclined surface 25 faces rearward and a portion thereof is disposed inside the depression 31 and another portion protrudes from the submerged surface 12 of the ship body.

[0016]

Further, as the material of the fluid guiding body 20 and the air induction pipe 21, those which provide a surface which is corrosion resistant primarily with respect to sea water and which is resistant to attachment of marine organisms, such as metals which have undergone some corrosion resistant treatment, or resins, etc., are preferably used. Also, the bubble generation apparatus 11 may be provided such that one or more units are arranged according to the breadth of the bottom of the ship. Reference symbols 28, 29 shown in Fig. 2(b) represent packing for the connecting flanges.

[0017]

Next, a method of reducing the frictional resistance of a ship body by means of the friction reducing ship M constituted as described above will be explained with reference to Fig. 1.

In the stationary state of the ship, water (seawater) ingresses into the fluid passage 30 (the internal space of the fluid guiding body 20 and the air induction pipe 21 shown in Fig. 2) to about the same level as that surrounding the ship body 10. When the ship body 10 begins to cruise using the thrust of the screw 13 (refer to Fig. 2), a flow of water 40 relative to the ship body 10 is formed.

[0018]

In the cruising state, at the bottom of the ship, the water passage is narrowed by the fore-inclined surface 24 of the fluid guiding body so that the flow velocity of water

flowing along the bottom of the ship increases, and the acute angle of the protruding end thereof forms a separation layer in the water. Such actions lead to local lowering of the static pressure in the water at the back side of the fore-inclined surface 24, i.e., the aft-inclined surface 25.

[0019]

Then, when the cruising speed of the ship body 10 reaches a certain ship speed Vs (standard cruising speed, for example), a negative pressure region 41, having a lower pressure relative to the atmosphere, is formed in the water at the aft-inclined surface 25.

[0020]

In this case, compared with the pressure at the air intake opening 21a, the pressure at the discharge opening 26 facing the negative pressure region 41 is low so that the fluid (seawater and air) inside the fluid passage 30 is subjected to a pressure gradient force such that the seawater is discharged from the fluid passage 30 and the air flowing in from the air intake opening 21a is ejected into the water by flowing through the fluid passage 30.

[0021]

Then, the gas ejected into the water becomes mixed in the water as air bubbles 42, and numerous bubbles 42 intervene in the vicinity of the submerged surface 12 of the ship body 10 leading to a reduction in the frictional resistance of the ship body 10.

[0022]

The energy required to eject the air into the water is primarily the energy for changing the position of the air. This energy is obtained by varying the flow conditions of the water by means of the fore-inclined surface 24 of the fluid guiding body, and is less than the energy consumed in compressing and ejecting the gas into the water. For this

reason, the energy expended in cruising is effectively reduced by lowering the frictional resistance of the ship body 10.

[0023]

In this case, in this embodiment, the discharge opening 26 for ejecting gas into the water is provided on the aft-inclined surface 25, which is disposed at an angle to the submerged surface 12 of the ship body. Therefore, compared with the case of disposing the discharge opening within a plane parallel to the submerged surface 12, the surface area of the opening of the discharge opening 26 within a given region of the submerged surface 12 of the ship body can be made large. Furthermore, this aft-inclined surface 25 is provided at both sides which sandwich the submerged surface 12 of the ship body extending from the inside portion to the outside portion of the depression 31, and a portion of the discharge opening 26 is disposed inside the depression 31. Therefore, the protrusion height of the fore-inclined surface 24 (and aft-inclined surface 25) from the submerged surface 12 of the ship body can be controlled even when a discharge opening 26 having a large opening area is provided, and it is less likely for there to be resistance to the flow of water 40.

[0024]

Therefore, in this embodiment, it is possible to eject a large amount of bubbles 42 from the discharge opening 26 having a large opening area while suppressing an increase in resistive force to the flow of water 40 so as to achieve an effective reduction in frictional resistance.

[0025]

Further, in the formation of the negative pressure region 41, the shape and Reynolds number of the fore-inclined surface 25 and aft-inclined surface 26 are the primary

governing factors, and disadvantages arising from the water depth are less likely to occur, so that the technology of this invention can be favorably applied to bulk ships.

[0026]

Here, the bubbles 42 mixed into the water are formed at a lower internal pressure than the static pressure resulting due to the water depth so that, when the bubbles 42 are moving through a constant water depth (for example, when the bubbles move along the bottom of the ship), a large water pressure acts on the bubbles 42 as they separate from the negative pressure region 41 so that the size of the bubbles 42 is gradually reduced. According to the results of research by the present applicants, it has been found that relatively smaller bubbles are preferable in reducing frictional resistance of the ship body. Therefore, the bubbles generated in the negative pressure region 41 are advantageously at work in reducing the frictional resistance.

[0027]

Also, the bubble generation apparatus 11 has a simple constitution, and a device for compressing gas is not required so that it is obvious that the construction cost of the ship body 10 is less.

[0028]

Also, the shapes and combination of each component shown in this embodiment are just examples, and various modifications within the scope of this invention based on design requirements are possible. For example, in the above embodiment, an example of applying this invention to a bulk ship is given, but it is not limited to such an application, and it is applicable to other ships such as high-speed ships. The size, number and location of the bubble generation apparatus 11 are appropriately chosen according to the shape of the ship body.

[0029]

[Effects of the Invention]

As described above, according to this invention, by making use of a pressure gradient force, gas can be ejected into the water at a lower energy consumption as compared with compressing the gas, and it is possible to carry out reduction in frictional resistance of the ship body.

Furthermore, the discharge opening for ejecting bubbles is disposed on an inclined surface provided at an angle to the submerged surface of the ship body, and this inclined surface extends from the inside portion to the outside portion of a depression provided on the submerged surface of the ship body. Therefore, it is possible to eject a large volume of bubbles into the water from the discharge opening having a large opening area while suppressing an increase in the resistance force to the flow of water generated by an object projecting from the submerged surface of the ship body. Therefore, by means of the large volume of bubbles, it is possible to achieve an effective reduction in the frictional resistance, and reduce the energy consumption during cruising. Moreover, there is no need for a device for pressurizing gas, and it is possible to easily reduce the construction cost of the ship body.

[Brief Description of the Drawings]

[Figure 1] This is a conceptual drawing showing an example of a method for reducing the frictional resistance of a ship body using the friction reducing ship according to this invention.

[Figure 2] This is a structural diagram schematically showing one embodiment of applying the method of reducing frictional resistance of a ship body according to this invention to a vessel.

[Figure 3] This is a perspective view showing the overall constitution of the negative pressure forming section 23 of Fig. 2.

[Brief Description of the Reference Symbols]

M friction reducing ship

10 ship body

11 bubble generation apparatus

12 ship body outer hull (submerged surface)

15 water surface (waterline)

20 fluid guiding body

21 air induction pipe

24 fore-inclined surface (negative pressure forming section)

25 aft-inclined surface

26 discharge opening

30 fluid passage

21a air intake opening

31 depression

[Document Type] Abstract

[Abstract]

[Problem] To provide a friction reducing ship, in which it is possible to effectively reduce the energy consumption during cruising by carrying out reduction of frictional resistance at a low energy consumption.

[Means for Solving the Problem] In order to form a negative pressure region 41 in the water having a pressure lower than that in a gaseous space, a negative pressure forming section 24 protruding from a submerged surface 12 of a ship body, a discharge opening 26 for ejecting bubbles 42 toward the negative pressure region 41 in the water, and a fluid passage 30, having one end open to a gaseous space and having the other end open to the water by way of the discharge opening 26, for guiding the gas into the water from the gaseous space are formed, and the discharge opening 26 is provided on an inclined surface 25 disposed at an angle to the submerged surface 12 of the ship body.

[Elected Drawing] Figure 1

FIG. 1

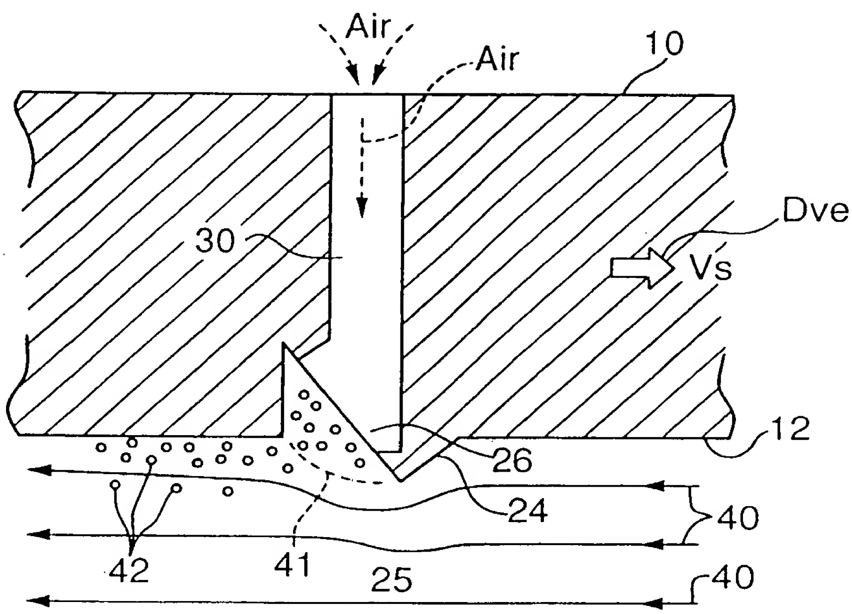

FIG. 2

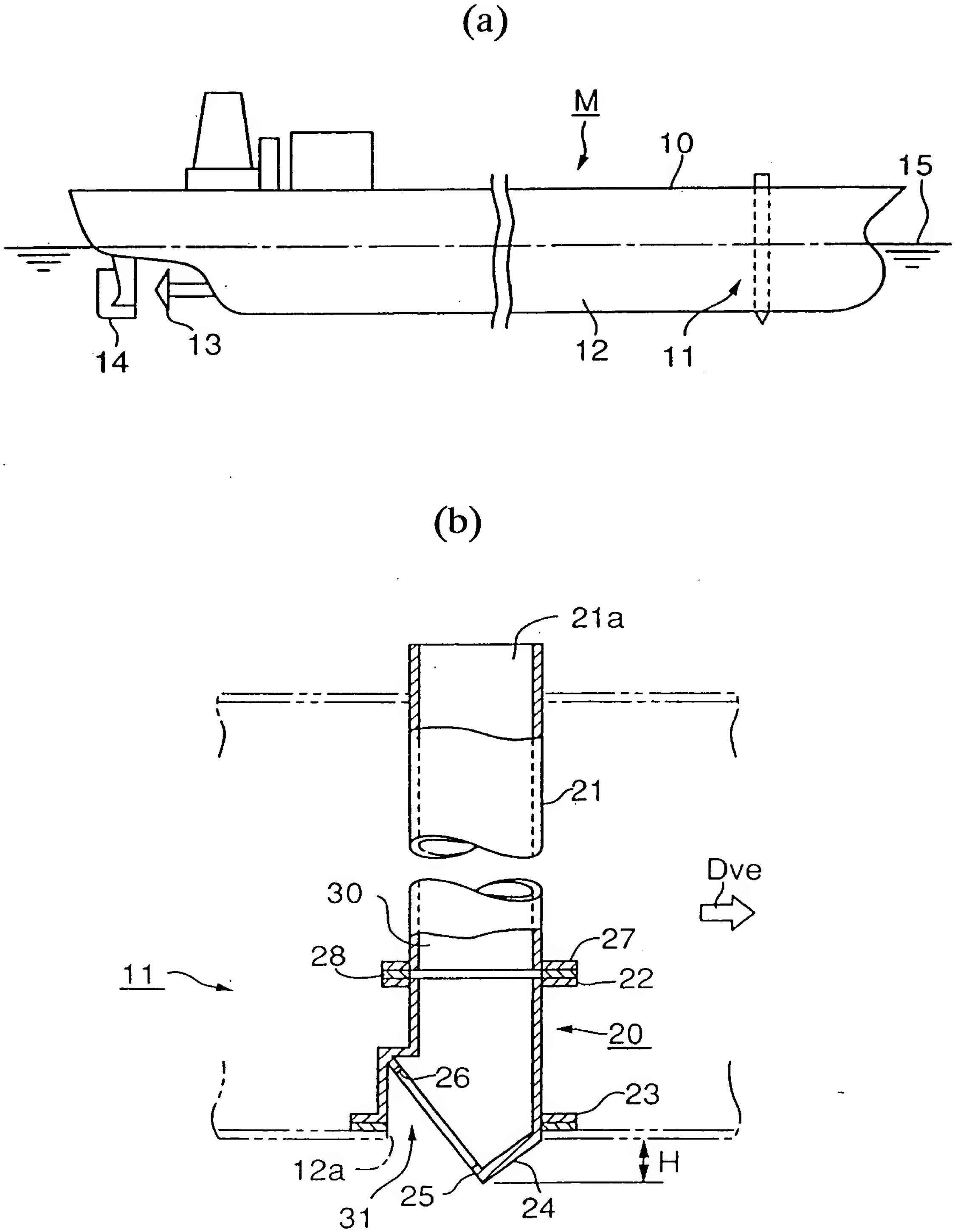

FIG. 3